Full Stack Development with MERN

Project Documentation

1. Introduction

Project Title: Shopez: E-Commerce Application

Team Members:

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2. Project Overview

Purpose:

The primary goal of this e-commerce platform is to **provide a seamless online shopping experience** for customers while enabling businesses to efficiently manage sales, inventory, and customer relationships.

Key Objectives:

- **For Customers:**
    - Offer a **user-friendly interface** to browse, search, and purchase products.
    - Ensure **secure transactions** with multiple payment options.
    - Provide **real-time order tracking** and personalized recommendations.
    - Enhance engagement with **discounts, wishlists, and reviews**.
- **For Businesses (Admin/Sellers):**
    - Streamline **product management** (adding, updating, and removing items).
    - Monitor **sales performance** through analytics and reports.
    - Automate **order processing** and inventory updates.
    - Improve customer retention with **promotions and loyalty programs**.

By bridging the gap between buyers and sellers, this platform aims to **boost sales, improve operational efficiency, and deliver a reliable digital marketplace**.

Features:

- **User Authentication** – Secure login, registration, and password recovery.
- **Product Catalog** – Organized categories, search functionality, and filters for easy navigation.
- **Shopping Cart & Checkout** – Cart management, multiple payment options, and order confirmation.
- **Order Management** – Order tracking, status updates, and automated invoice generation.

- **Admin Dashboard** – Product management (add, edit, delete), sales reports, and customer insights.

3. Architecture

Frontend:

The frontend is built with **React** in a **component-based architecture**, ensuring reusability, scalability, and maintainability. It follows modern best practices for state management, routing, and performance optimization.

Key Features of the Architecture:

- **Component-Based Structure** – Reusable UI components (buttons, cards, modals) organized in a structured hierarchy.
- **State Management** – **Redux Toolkit** for global state (cart, user auth) and **React Context** for localized state.
- **Routing** – **React Router v6** for seamless navigation between product pages, cart, and checkout.
- **Styling** – **TailwindCSS** or **CSS Modules** for maintainable and responsive designs.
- **API Integration** – **Axios** for HTTP requests with **React Query** for caching and data synchronization.
- **Form Handling** – **React Hook Form** with **Yup** for efficient validation in login, registration, and checkout.
- **Performance Optimization** – **Lazy loading**, code splitting, and memoization to reduce load times.
- **Testing** – **Jest** and **React Testing Library** for unit and integration tests.
- **Build Tool** – **Vite** for faster development and production builds.

Backend:

The backend is built with **Node.js** and **Express.js**, following a **modular, RESTful API** approach for scalability, security, and maintainability. It integrates with databases, authentication services, and third-party APIs to support frontend operations.

Key Components of the Architecture:

- **RESTful API Structure** – Organized routes for products, users, orders, and payments with proper HTTP methods (GET, POST, PUT, DELETE).
- **Middleware Layer** – Includes authentication (JWT/OAuth), request validation, error handling, and rate limiting.
- **Database Integration** – **MongoDB** (NoSQL) or **PostgreSQL** (SQL) with **Mongoose/Sequelize** for structured data modeling.
- **Authentication & Authorization** – Secure user login, registration, and role-based access control (RBAC) for admin/customer roles.

- **Payment Processing** – **Stripe/PayPal API** integration for secure transactions with webhook verification.
- **File Uploads** – **Multer** for handling product images and user avatars with cloud storage (AWS S3, Firebase).
- **Caching** – **Redis** for frequently accessed data (product listings, session management) to improve performance.
- **Logging & Monitoring** – **Winston/Morgan** for request logging and **Prometheus/Grafana** for performance metrics.
- **Security** – **Helmet.js** for HTTP headers, **CORS** policies, and input sanitization to prevent XSS/SQL injection.
- **Testing** – **Jest/Supertest** for unit and integration testing of API endpoints.
- **Deployment** – Containerized with **Docker** and deployed on **AWS/Heroku** with CI/CD pipelines (GitHub Actions).

Database:

The database leverages **MongoDB's flexible NoSQL structure** with collections designed for optimal query performance in e-commerce operations. All collections use **Mongoose schemas** for data validation and consistency.

Core Collections & Schemas

1. Users Collection

- **Fields:**
    - _id (ObjectId)
    - name (String, required)
    - email (String, unique, required)
    - password (String, hashed)
    - role (String: "user" or "admin")
    - addresses (Array of embedded documents: street, city, zip)
    - createdAt (Date)

2. Products Collection

- **Fields:**
    - _id (ObjectId)
    - name (String, required)
    - price (Number, required)
    - description (String)
    - category (String: "electronics", "clothing", etc.)

    - stock (Number)
    - images (Array of URLs)
    - reviews (Array referencing Review collection)

3. Orders Collection

- **Fields:**
    - _id (ObjectId)
    - user (ObjectId, ref: "User")
    - products (Array of subdocuments: productId, quantity, price)
    - totalAmount (Number)
    - status (String: "pending", "shipped", "delivered")
    - paymentId (String, from Stripe/PayPal)
    - createdAt (Date)

4. Reviews Collection

- **Fields:**
    - _id (ObjectId)
    - product (ObjectId, ref: "Product")
    - user (ObjectId, ref: "User")
    - rating (Number, min:1, max:5)
    - comment (String)

5. Carts Collection

- **Fields:**
    - _id (ObjectId)
    - user (ObjectId, ref: "User", unique)
    - items (Array of subdocuments: productId, quantity)
    - updatedAt (Date)

Key Database Interactions

1. User Operations

- **Signup:** Insert into Users after password hashing.
- **Login:** Query Users for email, verify password (bcrypt).
- **Profile Update:** Update Users with new address/password.

2. Product Operations

- **Listing:** Query Products with filters (category, price range).
- **Stock Management:** Decrement stock on order placement.

3. Order Workflow

- **Checkout:** Create Order, clear Cart, deduct Product.stock.
- **Status Updates:** Modify Order.status (admin-only).

4. Reviews & Ratings

- **Add Review:** Insert into Reviews, link to Product.reviews.
- **Aggregate Ratings:** Calculate average rating on Product lookup.

5. Cart Management

- **Add to Cart:** Upsert Cart.items array.
- **Sync Cart:** Merge guest/local cart with user cart on login.

Performance Optimizations

- **Indexes:**
    - Users.email (unique), Products.category, Orders.user.
- **References vs. Embedding:**
    - Embed Cart.items for atomic updates.
    - Reference Product in Orders to avoid data duplication.
- **Caching:**
    - Cache frequent queries (e.g., featured products) with **Redis**.

4. Setup Instructions

Prerequisites:

To set up and run the **e-commerce website**, ensure the following software and tools are installed:

Core Backend Dependencies

- **Node.js** (v18.x or later) – JavaScript runtime for the server.
- **Express.js** (v4.x) – Web framework for building RESTful APIs.
- **MongoDB** (v6.x or later) – NoSQL database for product/user/order data.
- **Mongoose** (v7.x) – ODM library for MongoDB schema modeling.

Development & Tools

- **npm** (v9.x+) or **Yarn** (v1.22+) – Package managers.
- **Postman** / **Insomnia** – API testing tools.

- **Git** – Version control system.
- **Docker** (Optional) – For containerized MongoDB/Redis deployment.

Additional Backend Libraries

- **jsonwebtoken** – For JWT-based authentication.
- **bcryptjs** – Password hashing.
- **dotenv** – Environment variable management.
- **cors** – Cross-Origin Resource Sharing middleware.
- **helmet** – HTTP security headers.
- **multer** – File upload handling.
- **stripe** / **paypal-rest-sdk** – Payment gateway integration.
- **winston** / **morgan** – Request logging.
- **joi** / **yup** – Request validation.
- **jest** / **supertest** – API testing.

Frontend Dependencies (if applicable)

- **React** (v18.x) – Frontend library.
- **React Router DOM** – Client-side routing.
- **Axios** – HTTP client for API calls.
- **Redux Toolkit** / **React Query** – State management.

Infrastructure (Optional)

- **Redis** – Caching layer.
- **AWS S3** / **Firebase Storage** – Cloud file storage.
- **NGINX** – Reverse proxy (production).

Installation Instructions

1. **Install Node.js** from nodejs.org.
2. **Install MongoDB** locally or use **MongoDB Atlas** (cloud).
3. Clone the repository and run:

   ```
   npm install
   ```

4. Set up environment variables (.env file) for:
   - MONGODB_URI
   - JWT_SECRET
   - STRIPE_API_KEY

Installation:

1. Clone the Repository

```
git clone https://github.com/your-repo/ecommerce-website.git

cd ecommerce-website
```

2. Backend Setup

Install Dependencies

```
cd backend

npm install  # or yarn install
```

Set Up Environment Variables

Create a .env file in the backend folder and add:

```
# MongoDB Configuration

MONGODB_URI=mongodb://localhost:27017/ecommerce  # Replace with Atlas URI if using cloud


# JWT Authentication

JWT_SECRET=your_jwt_secret_key

JWT_EXPIRES_IN=30d


# Payment Gateway (Stripe)

STRIPE_API_KEY=your_stripe_secret_key


# Server Port

PORT=5000


# Optional (if using Redis/Mail Service)

REDIS_URL=redis://localhost:6379

EMAIL_HOST=smtp.gmail.com

EMAIL_PORT=587

EMAIL_USER=your_email@gmail.com

EMAIL_PASS=your_email_password
```

Start the Backend Server

```
npm start  # Dev mode: `npm run dev` (with nodemon)
```

3. Frontend Setup

Install Dependencies

```
cd ../frontend

npm install  # or yarn install
```

Set Up Environment Variables

Create a .env file in the frontend folder and add:

```
# API Base URL

REACT_APP_API_URL=http://localhost:5000/api/v1  # Match backend PORT


# Stripe Public Key (for frontend)

REACT_APP_STRIPE_PUBLIC_KEY=your_stripe_public_key
```

Start the Frontend Development Server

npm start # Runs on http://localhost:3000

4. Database Initialization

- Ensure **MongoDB** is running locally or via [MongoDB Atlas]().
- Seed sample data (if applicable):

```
cd backend

npm run seed  # Runs predefined database seeder script
```

Verify the Setup

1. **Backend**: Access API docs at http://localhost:5000/api-docs (if using Swagger).
2. **Frontend**: Open http://localhost:3000 in your browser.
3. **Test Endpoints**: Use Postman to check:
    - GET /api/v1/products
    - POST /api/v1/auth/login

Troubleshooting

- **Dependency Errors**: Delete node_modules and rerun npm install.
- **MongoDB Connection**: Verify MONGODB_URI in .env matches your database (local/cloud).
- **CORS Issues**: Ensure backend has cors() middleware enabled.

5. Folder Structure

Client:

```
src/
 ├── assets/            # Static files (images, fonts, icons)
 ├── components/        # Reusable UI components
|    ├── common/        # Shared components (buttons, modals, loaders)
|    ├── layout/        # Layout components (header, footer, sidebar)
|   └── ui/             # Styled elements (cards, forms, grids)
 ├── pages/             # Route-based page components
|    ├── Home/          # Landing page
|    ├── Product/       # Product listing & details
|    ├── Cart/          # Shopping cart
|    ├── Checkout/      # Checkout flow
|    ├── Auth/          # Login, signup, password reset
|   └── Dashboard/      # User/admin dashboard
 ├── hooks/             # Custom React hooks
 ├── context/           # React context providers (auth, cart)
 ├── utils/             # Helper functions (formatters, API calls)
 ├── services/          # API service layer (Axios config)
 ├── styles/            # Global CSS/Tailwind/SASS files
 ├── store/             # Redux store (slices, actions)
 ├── routes/            # App routing logic
└── App.js              # Root component with routes
```

Key Components

1. Reusable UI Components (components/**)**

- Button, Input, Modal: Shared across pages.
- ProductCard: Displays product image, price, and "Add to Cart" action.
- RatingStars: Dynamic star ratings for reviews.

2. Pages (pages/**)**

- **Home**: Hero banner, featured products, promotions.

- **Product Listing**: Filterable grid of products with search.
- **Product Details**: Image gallery, price, description, reviews.
- **Cart**: Summary of items with quantity adjustments.
- **Checkout**: Multi-step form (shipping → payment → confirmation).
- **Auth**: Forms for login, registration, and password reset.

3. State Management

- **Redux Toolkit**: Manages global state (cart, user auth, products).
    - Slices: cartSlice, authSlice, productSlice.
- **React Context**: For theme toggling or local state.

4. Routing (routes/**)**

- **Public Routes**: Home, product pages, auth.
- **Private Routes**: User dashboard, checkout (requires auth).
- **Admin Routes**: Product management, orders (role-based).

5. API Services (services/**)**

- api.js: Axios instance with base URL and interceptors.
- productService.js, authService.js: Modular API calls.

6. Styling

- **TailwindCSS**: Utility-first styling with custom themes.
- **CSS Modules**: Scoped styles for components.

Server:

```
backend/
├── config/          # Configuration files
│   ├── db.js        # Database connection setup
│   └── env.js       # Environment validation
├── controllers/     # Route handlers
│   ├── authController.js
│   ├── productController.js
│   └── orderController.js
├── routes/          # Route definitions
│   ├── authRoutes.js
│   ├── productRoutes.js
```

```
|  └── index.js       # Main router
├── models/           # MongoDB schemas
|   ├── User.js
|   ├── Product.js
|  └── Order.js
├── middleware/        # Custom middleware
|   ├── auth.js        # Authentication
|   ├── error.js       # Error handling
|  └── validate.js     # Request validation
├── services/          # Business logic
|   ├── authService.js
|   ├── paymentService.js
|  └── emailService.js
├── utils/             # Helpers and utilities
|   ├── logger.js
|   ├── apiFeatures.js   # Filtering/sorting
|  └── asyncHandler.js  # Async wrapper
├── public/            # Static files
├── uploads/           # User uploads
├── app.js             # Express app setup
└── server.js          # Server entry point
```

Key Components

1. **Entry Points**
   - server.js: Starts the HTTP server, handles graceful shutdown
   - app.js: Configures Express middleware (body-parser, cors, etc.)
2. **Routing Layer**
   - Route files define endpoints (/api/v1/products)
   - Delegates to controllers
3. **Controller Layer**
- Handles HTTP requests/responses
- Calls service layer for business logic

4. **Service Layer**
    - Contains core business logic
    - Handles transactions, external API calls

6. Running the Application

Frontend (React):

1. Navigate to the frontend directory:

   cd client

2. Install dependencies (if not already installed):

   npm install

3. Start the development server:

   npm start

Backend (Node.js/Express)

1. Navigate to the backend directory:

   cd server

2. Install dependencies (if not already installed):

   npm install

3. Start the server:

   npm start

7. API Documentation

he backend API follows **RESTful principles** with JWT authentication. All endpoints return JSON responses.

Base URL

- http://localhost:5000/api/v1 (development)
- https://api.yourdomain.com/api/v1 (production)

Authentication

- **Required for protected routes**: Include JWT in headers:

  Authorization: Bearer <token>

Auth Endpoints

- **Register User**
    - POST /auth/register
    - Body: { name, email, password, role? }

    - Returns: { user, token }
- **Login User**
    - POST /auth/login
    - Body: { email, password }
    - Returns: { user, token }
- **Get Current User**
    - GET /auth/me
    - Returns: { user }

Product Management

- **Get All Products**
    - GET /products
    - Query Params: ?category=electronics&price[gte]=100
    - Returns: { products, count }
- **Create Product (Admin)**
    - POST /products
    - Body: { name, price, description, category, stock, images? }

Order Processing

- **Create Order**
    - POST /orders
    - Body: { products: [{ productId, quantity }], shippingAddress }
- **Get User Orders**
    - GET /orders/my-orders

Error Responses

- 401 Unauthorized: Invalid/missing token
- 404 Not Found: Resource doesn't exist
- 500 Server Error: Generic server failure

8. Authentication

The e-commerce platform uses **JWT (JSON Web Tokens)** for secure user authentication and authorization. Below are the key components and workflows:

1. Authentication Flow

- **Registration**:

    - User submits email, password, and other details.
    - Password is **hashed** (using bcryptjs) before storage.
    - A **JWT token** is generated and returned upon success.
- **Login**:
    - User provides email and password.
    - System verifies credentials against the database.
    - On success, returns a **JWT token** for subsequent requests.
- **Protected Routes**:
    - Client includes the JWT token in the Authorization header.
    - Server validates the token and grants access to authorized users.

2. Key Features

- **JWT Token**:
    - Signed with a **secret key** (JWT_SECRET in .env).
    - Contains **user ID** and **role** (e.g., user or admin).
    - Expires after a set duration (e.g., 30d).
- **Password Security**:
    - Passwords are **never stored in plaintext** (always hashed).
    - Uses **bcryptjs** for slow hashing (thwarts brute-force attacks).
- **Role-Based Access Control (RBAC)**:
    - Admins can access protected routes (e.g., product management).
    - Users can only modify their own data (e.g., profile, orders).

3. Security Measures

- **Rate Limiting**: Prevents brute-force login attempts.
- **HTTPS**: Encrypts all requests (mandatory in production).
- **Token Blacklisting**: (Optional) For immediate logout/session invalidation.

4. Example Request/Response

Login Request:

```
POST /api/v1/auth/login

{

  "email": "user@example.com",

  "password": "securePassword123"
}
```

Success Response:

```
{
  "token": "eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...",
  "user": {
    "id": "123",
    "name": "John Doe",
    "email": "user@example.com",
    "role": "user"
  }
}
```

9. User Interface

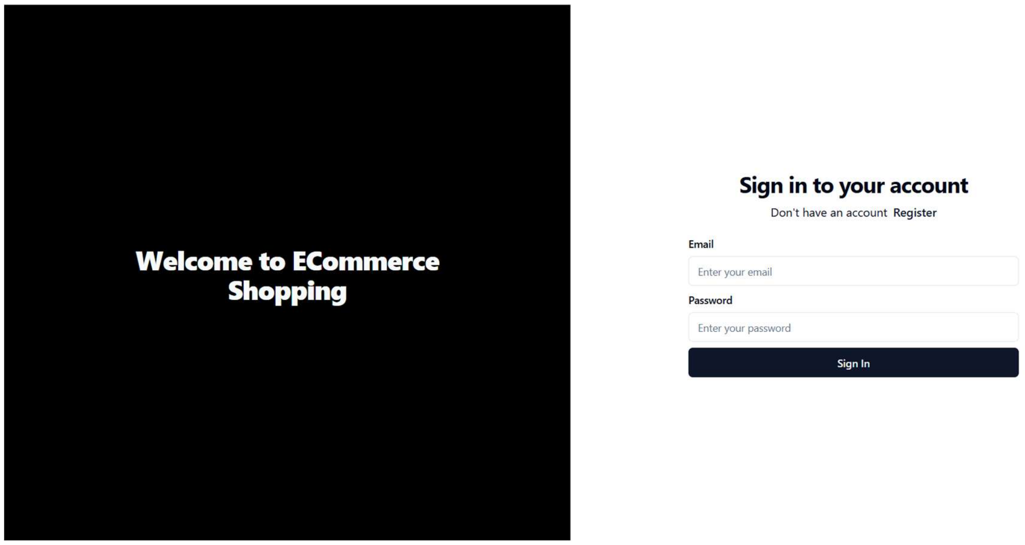


Fig 9.1 Sign-in Page

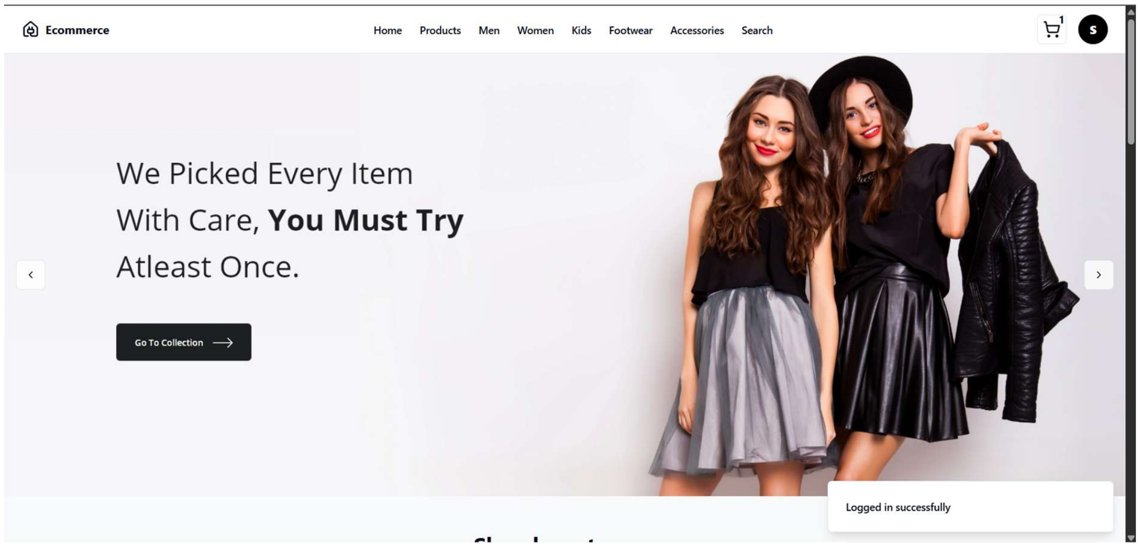
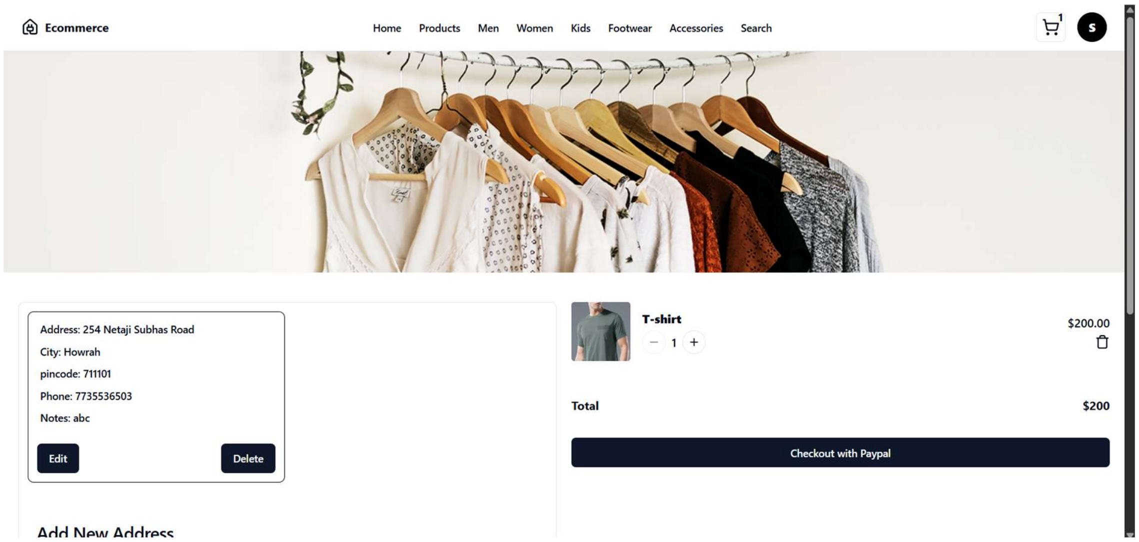


Fig 9.2 Home Page



Address: 254 Netaji Subhas Road
City: Howrah
pincode: 711101
Phone: 7735536503
Notes: abc

T-shirt 1 $200.00

Total $200

Fig 9.3 Cart

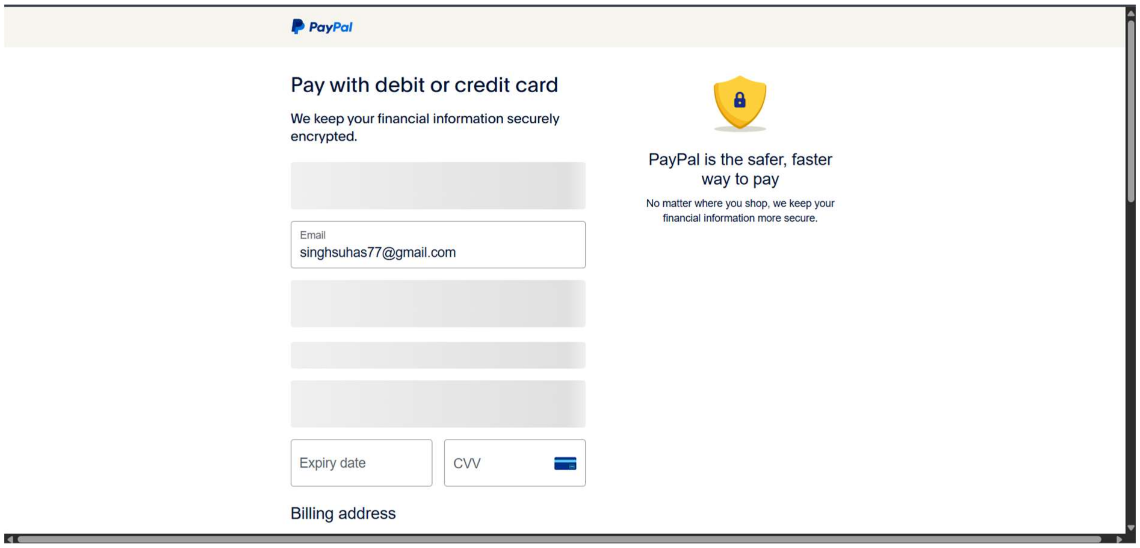

PayPal
Pay with debit or credit card
We keep your financial information securely encrypted.
Email
singhsuhas77@gmail.com
Expiry date
CVV
Billing address
PayPal is the safer, faster way to pay
No matter where you shop, we keep your financial information more secure.

Fig 9.4 Payment Gateway

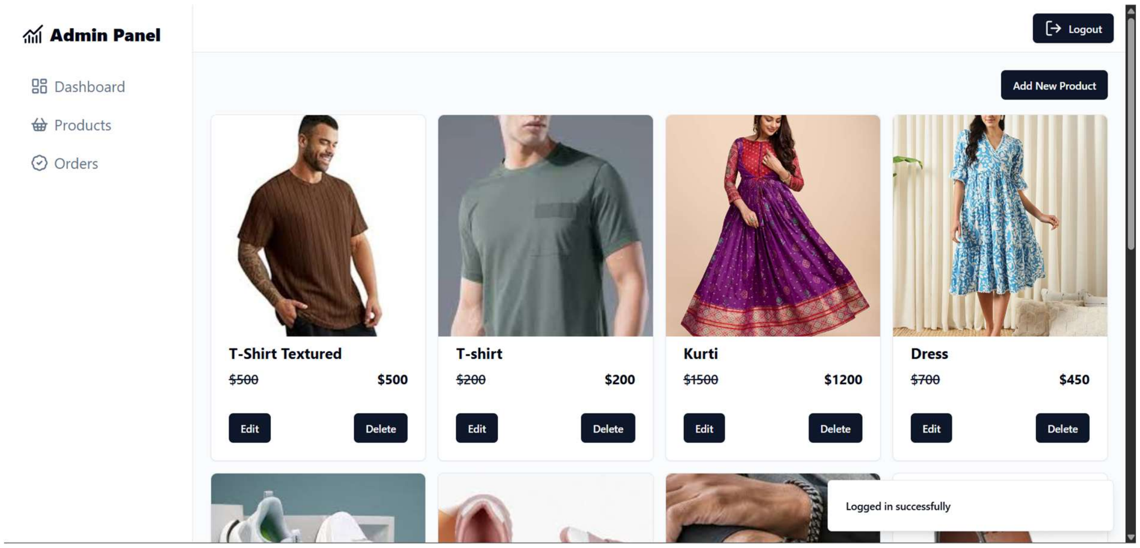
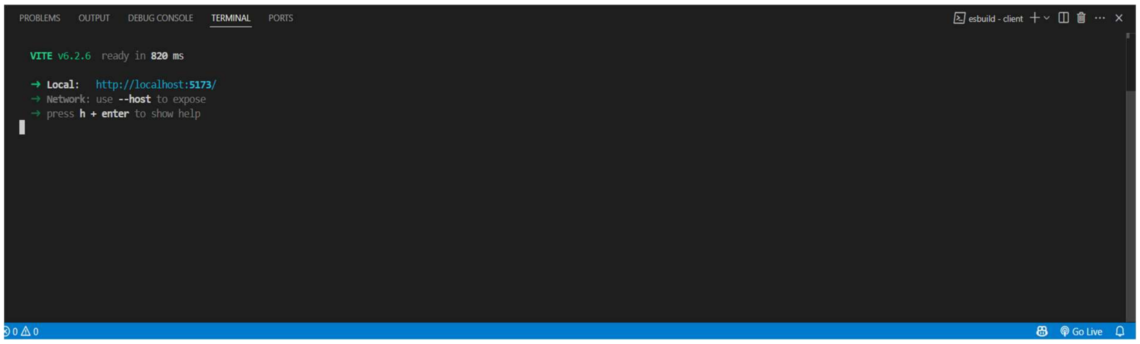


Fig 9.5 Admin Page

10. Testing

Time taken to deploy localhost:



```
  VITE v6.2.6  ready in 820 ms

  ➜  Local:   http://localhost:5173/
  ➜  Network: use --host to expose
  ➜  press h + enter to show help
```

11. Demo

https://drive.google.com/file/d/1Hp-jdoz9awVv1Jxf7mpCLaRWd7o7KK8B/view?usp=sharing

12. Known Issues

The following are **current limitations and bugs** in the e-commerce platform, along with their status and potential workarounds:

1. Authentication & Security

- **Issue**: JWT tokens cannot be invalidated before expiration.
  - **Impact**: Users remain logged in even after password changes.
  - **Workaround**: Implement a token blacklist or use shorter expiry times.
  - **Status**: *Planned fix (v2.0)*
- **Issue**: Password reset emails occasionally land in spam folders.
  - **Cause**: SMTP configuration lacks proper DKIM/DMARC records.
  - **Workaround**: Manually check spam or use a dedicated email service (e.g., SendGrid).
  - **Status**: *Under investigation*

2. Performance

- **Issue**: Product listing slows down with >10,000 items.
  - **Cause**: No pagination or indexing on MongoDB queries.
  - **Workaround**: Add ?limit=20&page=1 to API calls.
  - **Status**: *Fixed in dev branch*
- **Issue**: Images load slowly on mobile networks.
  - **Cause**: No lazy loading or image compression.
  - **Workaround**: Use loading="lazy" in <img> tags.
  - **Status**: *Patch coming soon*

3. Payment Processing

- **Issue**: Stripe webhooks sometimes fail during high traffic.
  - **Cause**: No retry mechanism for failed requests.
  - **Workaround**: Manually verify payments in Stripe dashboard.
  - **Status**: *Monitoring*
- **Issue**: PayPal payments do not sync immediately with the database.
  - **Cause**: Asynchronous webhook delays.
  - **Workaround**: Add a "Refresh Status" button in the order history.

    - **Status**: *Pending fix*

4. UI/UX Bugs

- **Issue**: Cart items disappear after page refresh in guest mode.
    - **Cause**: LocalStorage not synced with server on login.
    - **Workaround**: Merge guest cart with user cart manually.
    - **Status**: *Planned fix (v1.5)*
- **Issue**: Mobile menu collapses during checkout on iOS.
    - **Cause**: Safari CSS viewport bug.
    - **Workaround**: Use a fixed-height container.
    - **Status**: *Patch submitted*

13. Future Enhancements

The e-commerce platform is designed with scalability and adaptability in mind, ensuring it can evolve with technological advancements and changing market trends. Below are key areas for future expansion and enhancement:

1. Advanced Personalization

- Integration of **AI-driven recommendations** based on user behavior and purchase history.
- Implementation of **dynamic pricing** strategies tailored to individual customers.

2. Enhanced Mobile Experience

- Development of a **dedicated mobile app** with features like AR-based product visualization and one-click purchasing.
- Optimization for **progressive web apps (PWAs)** to ensure offline accessibility and faster loading.

3. Omnichannel Integration

- Synchronization with **physical stores** for features like "buy online, pick up in-store" (BOPIS) and real-time inventory tracking.
- Support for **social commerce**, enabling purchases directly through social media platforms.

4. Expansion of Payment Options

- Adoption of **cryptocurrency payments** to cater to a broader audience.
- Integration with **buy now, pay later (BNPL)** services for flexible payment solutions.

5. Improved Logistics and Delivery

- Implementation of **drone or autonomous vehicle deliveries** for faster shipping.
- Partnerships with **local logistics providers** to reduce delivery times and costs.

6. Sustainability Initiatives

- Introduction of a **carbon footprint calculator** to help customers make eco-friendly choices.
- Options for **eco-friendly packaging** and rewards for sustainable shopping practices.

7. Advanced Analytics and AI

- Use of **predictive analytics** to forecast trends and optimize inventory.
- AI-powered **chatbots and virtual assistants** for 24/7 customer support.

8. Global Expansion

- **Multi-language and multi-currency support** to enter international markets.
- Compliance with **regional regulations** (e.g., GDPR, CCPA) to ensure data privacy and security.

9. Subscription and Loyalty Programs

- Launch of **subscription-based models** for recurring revenue.
- Enhanced **loyalty programs** with personalized rewards and exclusive offers.

10. Blockchain for Transparency

- Use of **blockchain technology** to ensure product authenticity and supply chain transparency.
- Secure and tamper-proof **customer reviews and ratings**.